

Power Distribution Unit (PDU)



PDU Overview

SPARCLE PDR

- **Description**

- The PDU is responsible for providing power to SPARCLE
- The PDU will consist of custom in-house designs and Commercial-Off-The-Shelf (COTS) hardware
- The PDU subsystem will consist of two boxes. One box will be located in the Computer Support Canister. The other box will be located in the Transceiver Support Canister.
- One Engineering Unit and one Flight Unit will be fabricated.

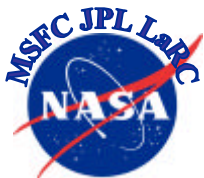


PDU Requirements

SPARCLE PDR

- **System Requirements**

- Power to each subsystem- except the PDU, CDMS, MSU- shall be commanded on/off by the CDMS
- Voltage telemetry will be provided to the HSS
- EMI/EMC as specified in MSFC-SPEC-521B
- EEE Parts as specified in MSFC-PLAN-2805
- Wiring as specified in MSFC-P09.1-C03
- Other manufacturing requirements as listed in paragraph 1.3 of MSFC-RQMT-2797

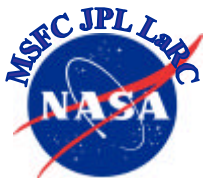


PDU Requirements

SPARCLE PDR

- **Hitchhiker Requirements**

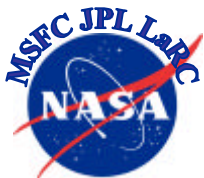
- Input Bus Voltage of +28V +/-4V with power quality as specified in ICD 2-19001 (Appendix H of the CARS document)
- Each PDU receives two 10 Amp circuits (500W per canister)
- Customers must provide consistent wiring and fusing within their payloads
- SPARCLE must provide all EMI filtering
- The 28V return must be isolated from both signal ground and case by a minimum resistance of 10K ohms. **This requirement cannot be waived.**



PDU Requirements

SPARCLE PDR

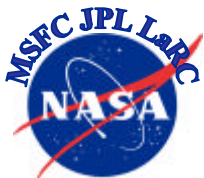
- **PDU to Subsystems Isolation Requirements**
 - primary power and return lines must be isolated from chassis by a min of 200K ohms and a max of 10 microfarads of capacitance
 - secondary power and return lines must be isolated from chassis by a min of 1 Meg ohm and a max of 10 microfarads of capacitance
 - primary and secondary power, supply and return, must be isolated by a min of 1 Meg ohm and a max of 1 microfarad of capacitance (all lines floating with respect to chassis)



PDU Requirements

SPARCLE PDR

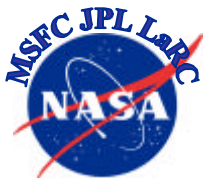
- **PDU Isolation Requirements**
 - primary power and return lines must be isolated from chassis by a min of 200K ohms and a max of 10 microfarads of capacitance
 - secondary return lines must be connected to chassis.
 - primary and secondary power, supply and return, must be isolated by a min of 1 Meg ohm and a max of 1 microfarad of capacitance (all lines floating with respect to chassis)



PDU Requirements- CDMS

SPARCLE PDR

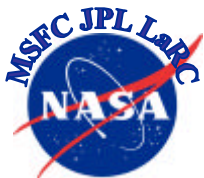
- **CDMS Input Power**
 - Voltage: Filtered 28V bus
 - Regulation: +/-4V
 - Ripple: Not Defined
 - Ave Power: 102W
- **Subsystem ON/OFF Command Interface**
 - ON/OFF commanding through six discrete TTL compatible lines
 - 3 address
 - 1 on command
 - 1 off command
 - 1 signal return



PDU Requirements- MSU

== SPARCLE PDR ==

Voltage (V)	Regulation (%V)	Ripple (mVp-p)	Power (W)
+12	+/-3	100	22
+5	+/-3	50	27.5

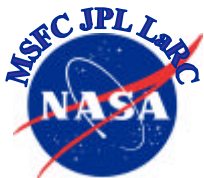


PDU Requirements- Lidar Transceiver

SPARCLE PDR

Voltage (V)	Regulation (%V)	Ripple (mVp-p)	Power (W)
+550	+/-3	TBD	55
+125	+/-3	TBD	87.5
+28	+/-3	200	19.6
+15	+/-3	85	12
-15	+/-3	85	12
+12	+/-3	200	96*
-12	+/-3	200	96*
-7	+/-3	TBD	38
+5	+/-3	60	6.5

*The total power of the +/-12V outputs will be 96W, but either output may source a total of 96W with the other output at 0W.

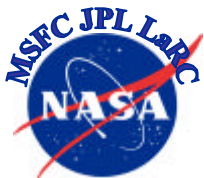


PDU Requirements- Scanner

== SPARCLE PDR ==

Voltage (V)	Regulation (%V)	Ripple (mVp-p)	Power (W)
+28 Bus	+/-14	TBD	78.4*
+12	+/-3	60	4.2
-12	+/-3	60	4.2
+5	+/-3	90	20

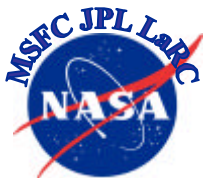
*Latest information



PDU Requirements- Health & Status

== SPARCLE PDR ==

Voltage (V)	Regulation (%V)	Ripple (mVp-p)	Power (W)
+12	+/-3	140	1.8
-12	+/-3	140	1.8
+5	+/-3	90	15.5
-5	+/-3	350	3

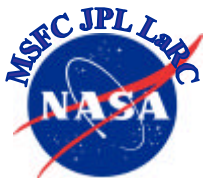


PDU Requirements- Health & Status (cont)

SPARCLE PDR

Voltage Scaling for Telemetry Circuits

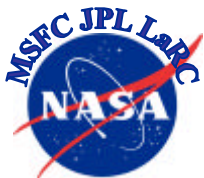
Output Voltage (V)	Telemetry Scaling Factor (V/V)	Nom. Telemetry Voltage (V)	Telemetry Voltage Range (V)
+550	0.00727	+4.0	+5.0
+125	0.032	+4.0	+5.0
+28	0.14285	+4.0	+5.0
+15	0.26667	+4.0	+5.0
-15	0.26667	-4.0	-5.0
+12	0.33333	+4.0	+5.0
-12	0.33333	-4.0	-5.0
-7	0.5714	-4.0	-5.0
+5	0.8	+4.0	+5.0
-5	0.8	-4.0	-5.0



PDU Requirements- Receiver

SPARCLE PDR

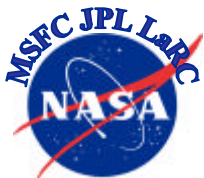
Voltage (V)	Regulation (%V)	Ripple (mVp-p)	Power (W)
+15	+/-3	90	22.5
-15	+/-3	170	3
+5	+/-3	150	1



PDU Requirements- INS/GPS

== SPARCLE PDR ==

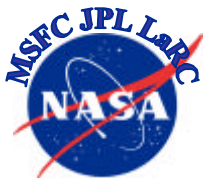
Voltage (V)	Regulation (%V)	Ripple (mVp-p)	Power (W)
+28 BUS	+/-14	TBD	40



PDU Requirements- Thermal Control

== SPARCLE PDR ==

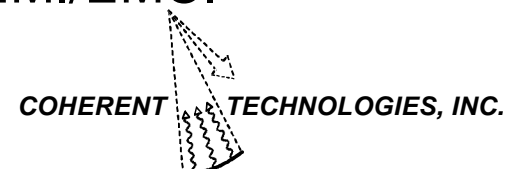
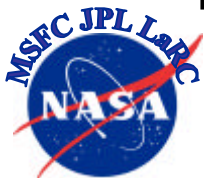
Voltage (V)	Regulation (%V)	Ripple (mVp-p)	Power (W)
+28 BUS	+/-14	TBD	TBD



PDU Design

SPARCLE PDR

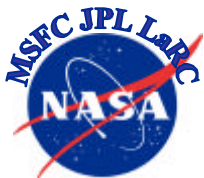
- **To meet System Requirements.**
 - Each PDU will have a CDMS interface board.
 - The boards will control the power supplied to each subsystem.
 - The PDU will provide buffered analog telemetry of the output voltages to the HSS.
 - The telemetry outputs are scaled representations of the actual output voltages.
 - The telemetry signals are referenced to secondary returns.
 - The telemetry of the +28V bus to the subsystems will be transformer isolated.
 - Each PDU engineering unit will be tested to the requirements of MSFC-SPEC-521B for EMI/EMC.



PDU Design

SPARCLE PDR

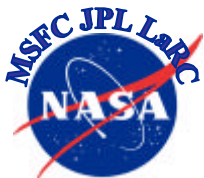
- **To meet System Requirements(cont).**
 - All parts selection will follow the guidelines as specified in MSFC-PLAN-2805 with the assistance of David Beeson of the EEE Parts Team, EB13.
 - Wiring and fusing will follow MSFC-P09.1-C03 with the assistance of Tom Dietrich of the Electrical Avionics Integration Branch, EB14.
 - Manufacturing of the PDU will be a combined effort between the designers, the Electronics Packaging Team, and other organizations responsible for the development of flight hardware.



PDU Design

SPARCLE PDR

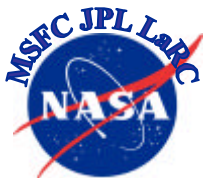
- **To meet Hitchhiker Requirements.**
 - The PDU engineering units will be tested at min, max, and nominal input voltages.
 - Tests will verify that no more than 10 Amps of input current per circuit feed will be used at full load.
 - Each circuit feed will be fused at 10 Amps to be consistent with the Hitchhiker.
 - Primary power feeds to the subsystems will be fused to protect the smaller gauge wire.
 - Perform analysis of the system to verify that the primary 28V return lines are isolated by a min of 10 K ohms from the signal ground and case.

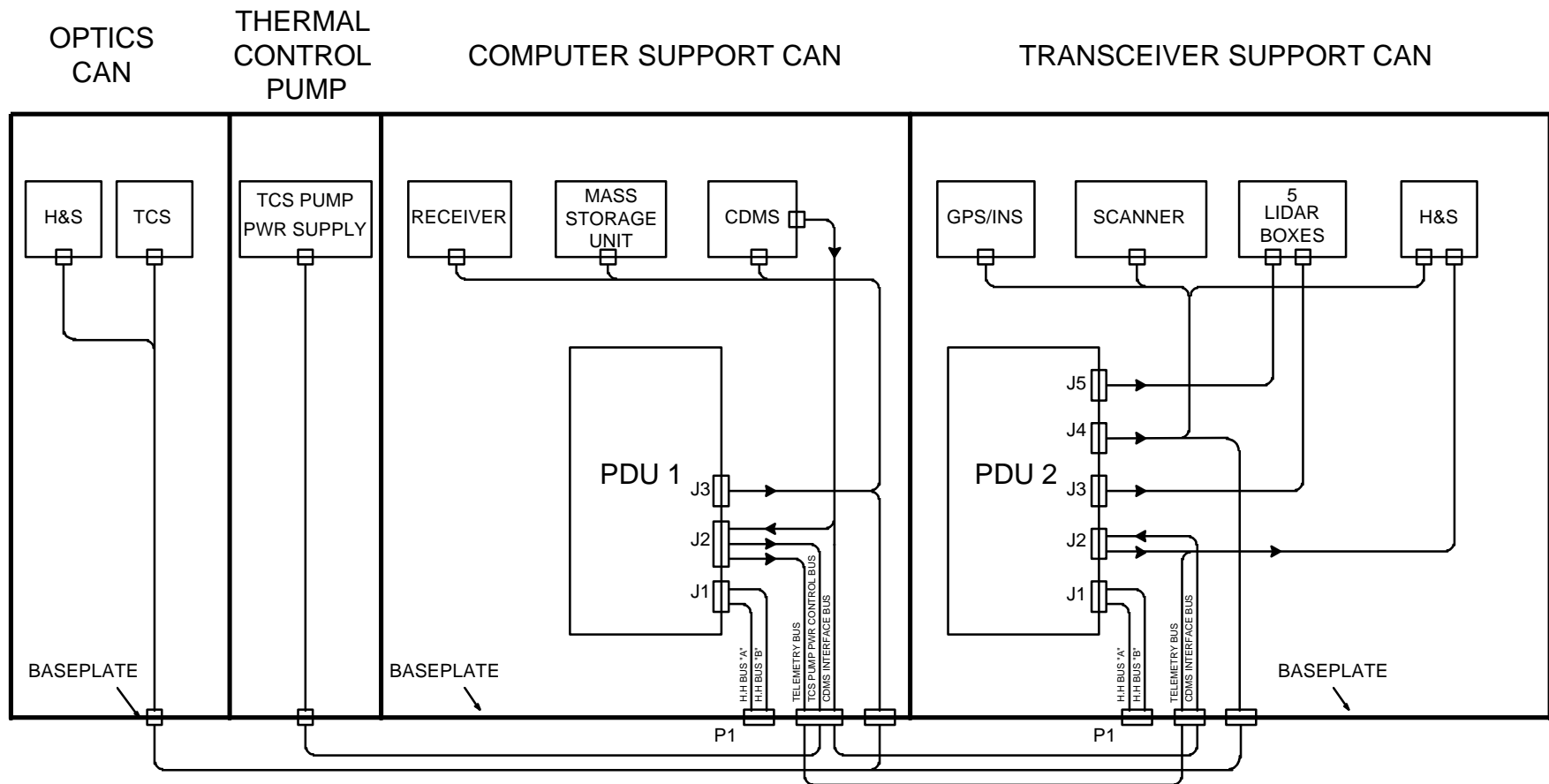


PDU Design

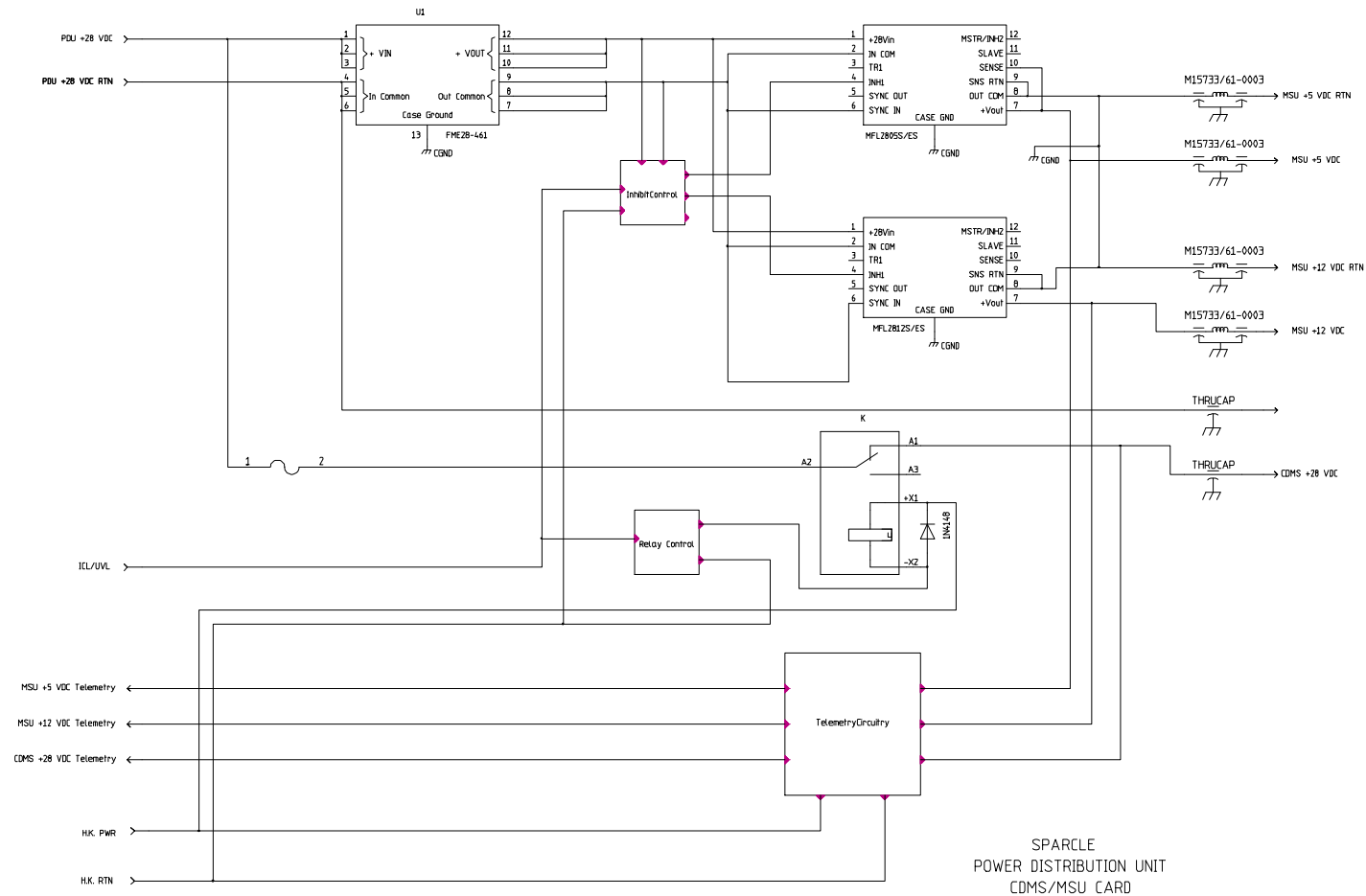
SPARCLE PDR

- **To meet Subsystem Requirements.**
 - C.O.T.S. supplies and in-house design supplies shall have output capacities greater than the maximum load requirements.
 - The Engineering Unit shall be tested over subsystem load ranges to ensure compliance with regulation and ripple requirements.
 - The Engineering Unit shall undergo environmental testing using simulated loads.





PDU Electrical Interconnect Diagram



CDMS/MSU

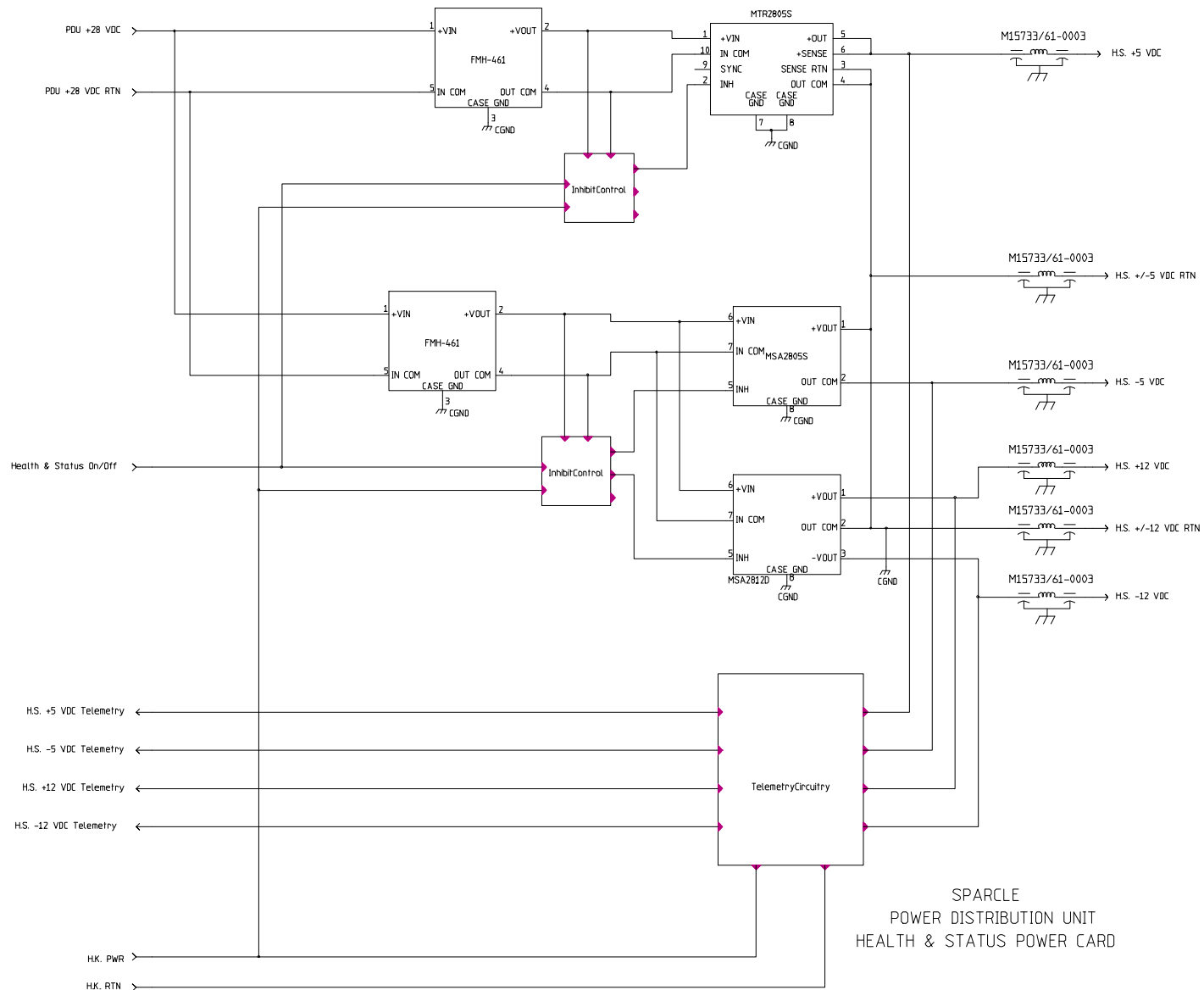
Supply Voltage (VDC)	Peak Load Current for CDMS and MSU (Amperes)		Total Peak Current (Amps.)	Total Peak Power (Watts)
	CDMS	MSU		
28	6.29	0.00	6.290	176.12
12	0.00	3.70	3.700	44.40
5	0.00	3.78	3.780	18.90

C.O.T.S Supplies								
Supply P.N.	Output Voltages	Maximum Power Available at Each Output (Watts)	Maximum Total Output Power (Watts)	Supply Qty.	Total Maximum Power Available at Each Output (Watts)	Total Maximum Total Output Power (Watts)	MSU Maximum Load (Watts)	Spare Capacity (Watts)
MFL2812S/ES	+12 VDC	60.00	60.00	1	60.00	60.00	44.400	15.600
MFL2805S/ES	+5 VDC	50.00	50.00	1	50.00	50.00	18.900	31.100

CDMS/MSU SUPPLIES		REGULATION	REGULATION REQUIREMENT
MFL2812S/ES	+12 VDC	+/- 0.040 VDC	+/- 0.36 VDC
MFL2805S/ES	+5 VDC	+/- 0.040 VDC	+/- 0.15 VDC

CDMS/MSU C.O.T.S. POWER SUPPLY FILTERS

Filter P.N.	Throughput Current (Amps.)			
FME28-461	15.00			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MFL2812S/ES	60.00	3.48	1	3.48
MFL2805S/ES	50.00	2.90	1	2.90
		Total:	6.38	



HEALTH AND STATUS SUBSYSTEM PEAK POWER CONSUMPTION

Supply Voltage (VDC)	Max.Load Current in H&S Boxes (Amperes)			Total Power (Watts)
	Optics Can	Transceiver Can	Total Current (Amps.)	
12	0.09	0.06	0.15	1.80
-12	0.09	0.06	0.15	1.80
5	1.41	1.80	3.21	16.05
-5	0.30	0.30	0.60	3.00

C.O.T.S Supplies								
Supply P.N.	Output Voltages	Maximum Power Available at Each Output (Watts)	Maximum Total Output Power (Watts)	Supply Qty.	Total Maximum Power Available at Each Output (Watts)	Total Maximum Total Output Power (Watts)	H&S Load (Watts)	Spare Capacity (Watts)
MSA2812D/ES	+12 VDC	4.00	5.00	1	4.00	5.00	3.60	1.40
	-12 VDC	4.00			4.00			
MTR2805S/ES	+5 VDC	25.00	25.00	1	25.00	25.00	16.05	8.95
MSA2805S/ES	-5 VDC	5.00	5.00	1	5.00	5.00	3.00	2.00

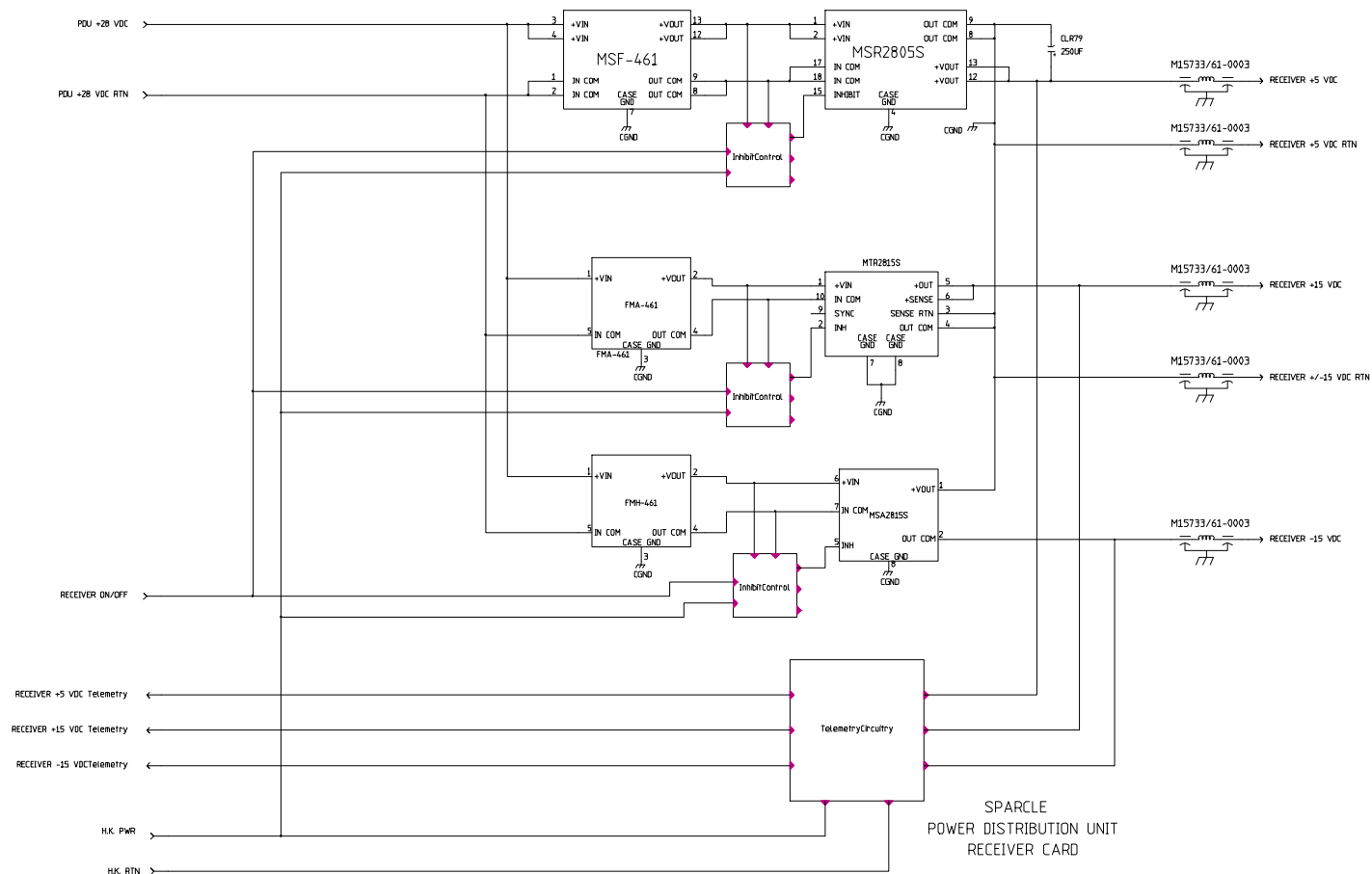
HEALTH AND STATUS SUPPLIES		REGULATION	REGULATION REQUIREMENT
MSA2812D/ES	+12 VDC	+/- 0.100 VDC	+/- 0.36 VDC
	-12 VDC	+/- 0.380 VDC*	+/- 0.36 VDC
MTR2805S/ES	+5 VDC	+/- 0.100 VDC	+/- 0.15 VDC
MSA2805S/ES	-5 VDC	+/- 0.100 VDC	+/- 0.15 VDC

* This regulation limit is partly based upon a line input of 16 VDC to 40 VDC. Tests shall be run to determine the regulation limits between 24 VDC and 32 VDC.

HEALTH & STATUS C.O.T.S. POWER SUPPLY FILTERS

Filter P.N.	Throughput Current (Amps.)			
FMH-461	1.50			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MSA2812D/ES	5.00	0.29	1	0.29
MSA2805S/ES	5.00	0.29	1	0.29
			Total:	0.58

Filter P.N.	Throughput Current (Amps.)			
FMH-461	1.50			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MTR2805S/ES	25.00	1.45	1	1.45
			Total:	1.45



ELECTRONICS RECEIVER POWER CONSUMPTION

Supply Voltage (VDC)	Load Current in Electronics Receiver (Amperes)	Total Power (Watts)
15	1.500	22.50
-15	0.200	3.00
5	0.200	1.00

C.O.T.S Supplies								
Supply P.N.	Output Voltages	Maximum Power Available at Each Output (Watts)	Maximum Total Output Power (Watts)	Supply Qty.	Total Maximum Power Available at Each Output (Watts)	Total Maximum Total Output Power (Watts)	Receiver Load (Watts)	Spare Capacity (Watts)
MTR2815S/ES	+15 VDC	30.00	30.00	1	30.00	30.00	22.50	7.50
MSA2815S/ES	-15 VDC	5.00	5.00	1	5.00	5.00	3.00	2.00
MSR2805S/ES	+5 VDC	3.50	3.50	1	3.50	3.50	1.00	2.50

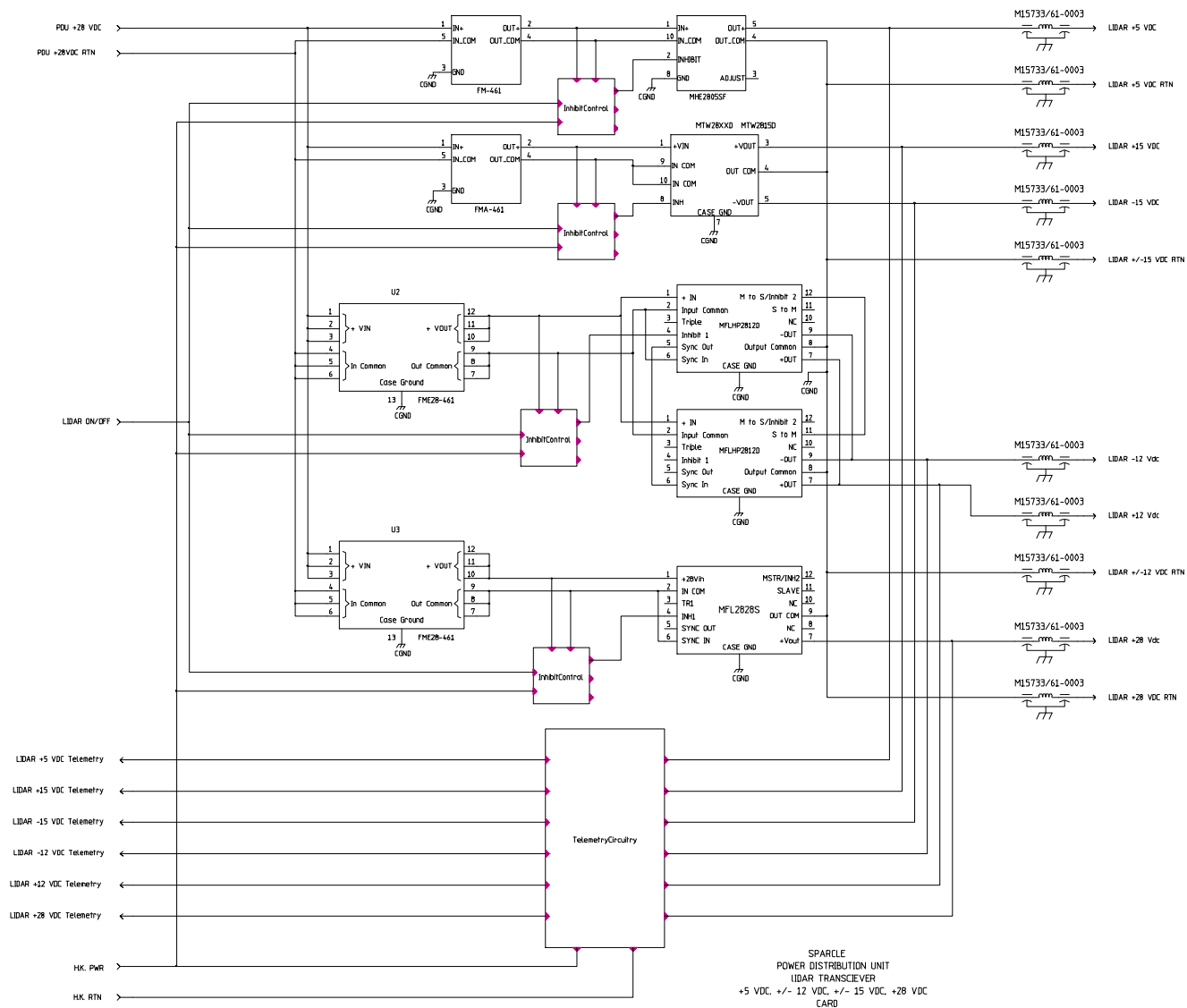
RECEIVER SUPPLIES		REGULATION	REGULATION REQUIREMENT
MTR2815S/ES	+15 VDC	+/- 0.100 VDC	+/- 0.45 VDC
MSA2815S/ES	-15 VDC	+/- 0.100 VDC	+/- 0.45 VDC
MSR2805S/ES	+5 VDC	+/- 0.060 VDC	+/- 0.15 VDC

ELECTRONICS RECEIVER C.O.T.S. POWER SUPPLY FILTERS

Filter P.N.	Throughput Current (Amps.)			
FMA-461	3.00			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MTR2815S/ES	30.00	1.74	1	1.74
			Total:	1.74

Filter P.N.	Throughput Current (Amps.)			
FMH-461	1.50			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MSA2815S/ES	5.00	0.29	1	0.29
			Total:	0.29

Filter P.N.	Throughput Current (Amps.)			
MSF-461	0.42			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MSR2805S/ES	3.50	0.20	1	0.20
			Total:	0.20



LIDAR TRANSCEIVER POWER CONSUMPTION

Supply Voltage (VDC)	Load Current in LIDAR Transceiver Boxes (Amperes)					Total Current (Amps.)	Total Power (Watts)
	MO/LO Control	Slave Pump Driver	MO Freq. Control	Q-Switch Driver	Ramp/Fire Control		
550	0.000	0.000	0.100	0.000	0.000	0.100	55.00
125	0.000	0.700	0.000	0.000	0.000	0.700	87.50
28	0.000	0.000	0.000	0.500	0.200	0.700	19.60
15	0.100	0.200	0.100	0.200	0.200	0.800	12.00
-15	0.100	0.200	0.100	0.200	0.200	0.800	12.00
12	8.000	0.000	0.000	0.000	0.000	8.000	96*
-12	8.000	0.000	0.000	0.000	0.000	8.000	96*
-7	5.400	0.000	0.000	0.000	0.000	5.400	37.80
5	0.000	0.200	0.700	0.200	0.200	1.300	6.50

C.O.T.S Supplies								
Supply P.N.	Output Voltages	Maximum Power Available at Each Output (Watts)	Maximum Total Output Power (Watts)	Supply Qty.	Total Maximum Power Available at Each Output (Watts)	Total Maximum Total Output Power (Watts)	LIDAR Load (Watts)	Spare Capacity (Watts)
MFL2828S/ES	+28 VDC	65.00	65.00	1	65.00	65.00	55.000	10.000
MTW2815D/ES	+15 VDC	27.00	30.00	1	27.00	30.00	24.000	6.000
	-15 VDC	27.00			27.00			
MFLHP2812D	+12 VDC	63.00	90.00	2	126.00	180.00	96*	30**
	-12 VDC	63.00			126.00			
MHE2805SF/ES	+5 VDC	15.00	15.00	1	15.00	15.00	6.500	8.500

* Maximum power Draw from +/-12 VDC supply shall not exceed 96 Watts

** Spare capacity based upon case where 96 watts is delivered by a single output

LIDAR SUPPLIES		REGULATION	REGULATION REQUIREMENT
MFL2828S/ES	+28 VDC	+/- 0.135 VDC	+/- 0.84 VDC
MTW2815D/ES	+15 VDC	+/- 0.075 VDC	+/- 0.45 VDC
	-15 VDC	+/- 0.075 VDC	+/- 0.45 VDC
MFLHP2812D	+12 VDC	UNKNOWN***	+/- 0.36 VDC
	-12 VDC	UNKNOWN***	+/- 0.36 VDC
MHE2805SF/ES	+5 VDC	+/- 0.025 VDC	+/- 0.15 VDC

*** Multiple units are connected in parallel. Tests shall be performed to determine regulation limits.

LIDAR C.O.T.S. POWER SUPPLY FILTERS

Filter P.N.	Throughput Current (Amps.)			
FM-461	1.75			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MHE2805SF/ES	15.00	0.87	1	0.87
			Total:	0.87

Filter P.N.	Throughput Current (Amps.)			
FMA-461	3.00			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MTW2815S/ES	30.00	1.74	1	1.74
			Total:	1.74

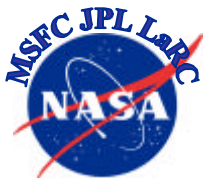
Filter P.N.	Throughput Current (Amps.)			
FME28-461	15.00			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MFL2828S/ES	65.00	3.77	1	3.77
			Total:	3.77

Filter P.N.	Throughput Current (Amps.)			
FME28-461	15.00			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MFLHP2812D/ES	90.00	5.22	2	10.43
			Total:	10.43

PDU Custom In-House Designs

== SPARCLE PDR ==

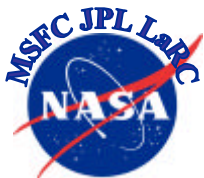
- **+550 V , 100 mA Isolated Output**
 - Input Voltage Range: 24 Vdc to 35 Vdc
 - 100 kHz Operating Frequency
 - Two potential design candidates.
 - Single Transformer, Push-Pull Converter Topology
 - Modified Boost-Add Regulator with a Capacitor-Diode Voltage Multiplier
 - +/-3% Regulation and TBD ripple voltage over line/load ranges
 - Short-circuit protection provided.



PDU Custom In-House Designs

== SPARCLE PDR ==

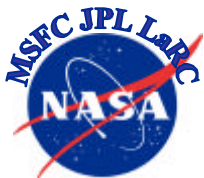
- **+125 V , 1 A Isolated Output**
 - Input Voltage Range: 24 Vdc to 35 Vdc
 - 100 kHz Operating Frequency
 - Single Transformer, Push-Pull Converter Topology
 - +/-3% Regulation and TBD ripple voltage over line/load ranges
 - Short-circuit protection provided.

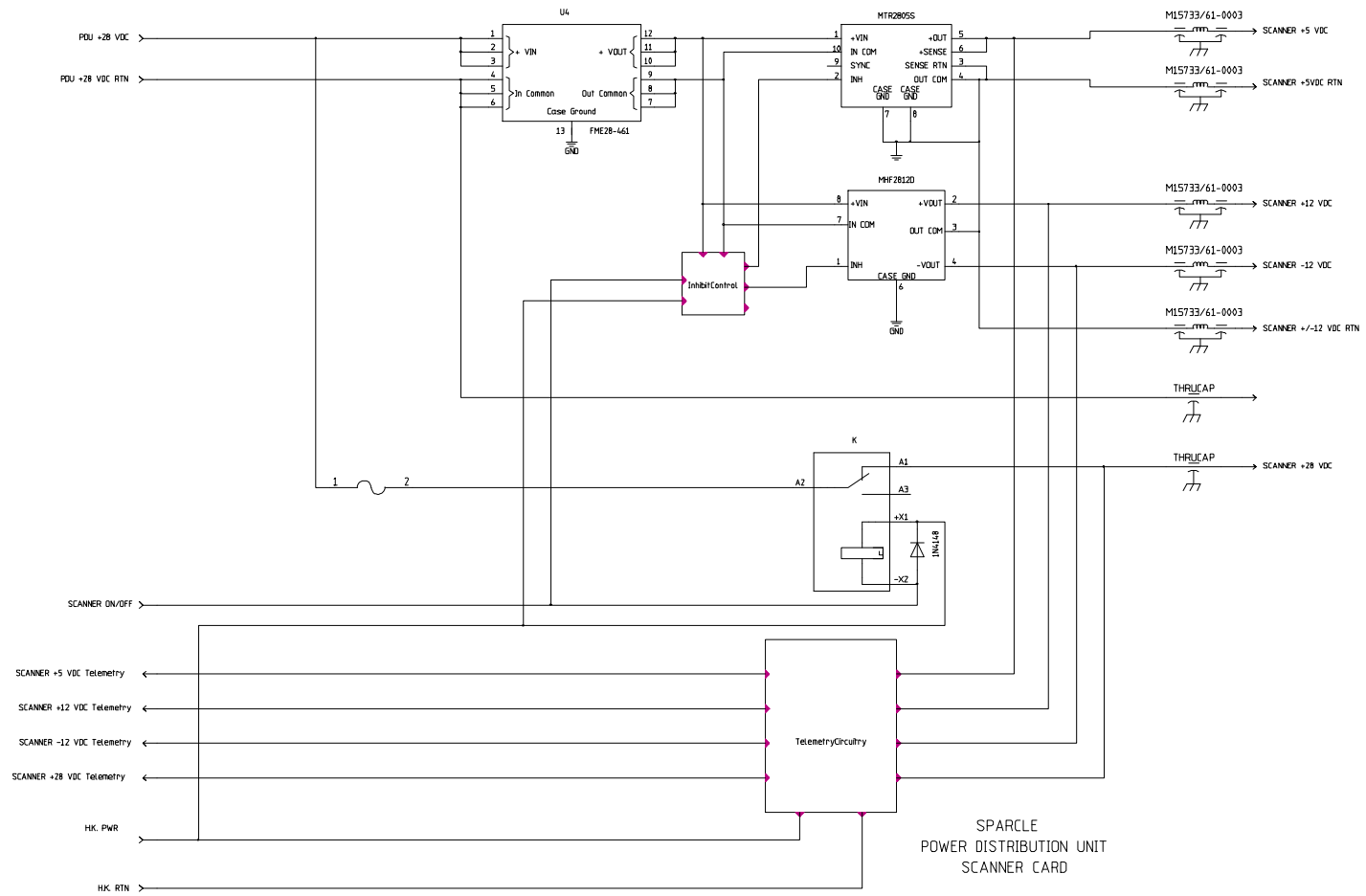


PDU Custom In-House Designs

■ SPARCLE PDR

- **-7 V , 6 A Isolated Output**
 - Input Voltage Range: 24 Vdc to 35 Vdc
 - 100 kHz Operating Frequency
 - Single Transformer, Forward Converter Topology
 - +/-3% Regulation and TBD ripple voltage over line/load ranges
 - Short-circuit protection provided.





SCANNER PEAK POWER CONSUMPTION

Supply Voltage (VDC)	Load Current in Scanner (Amperes)	Total Power (Watts)
28	3.00	84.00
12	0.35	4.20
-12	0.35	4.20
5	4.00	20.00

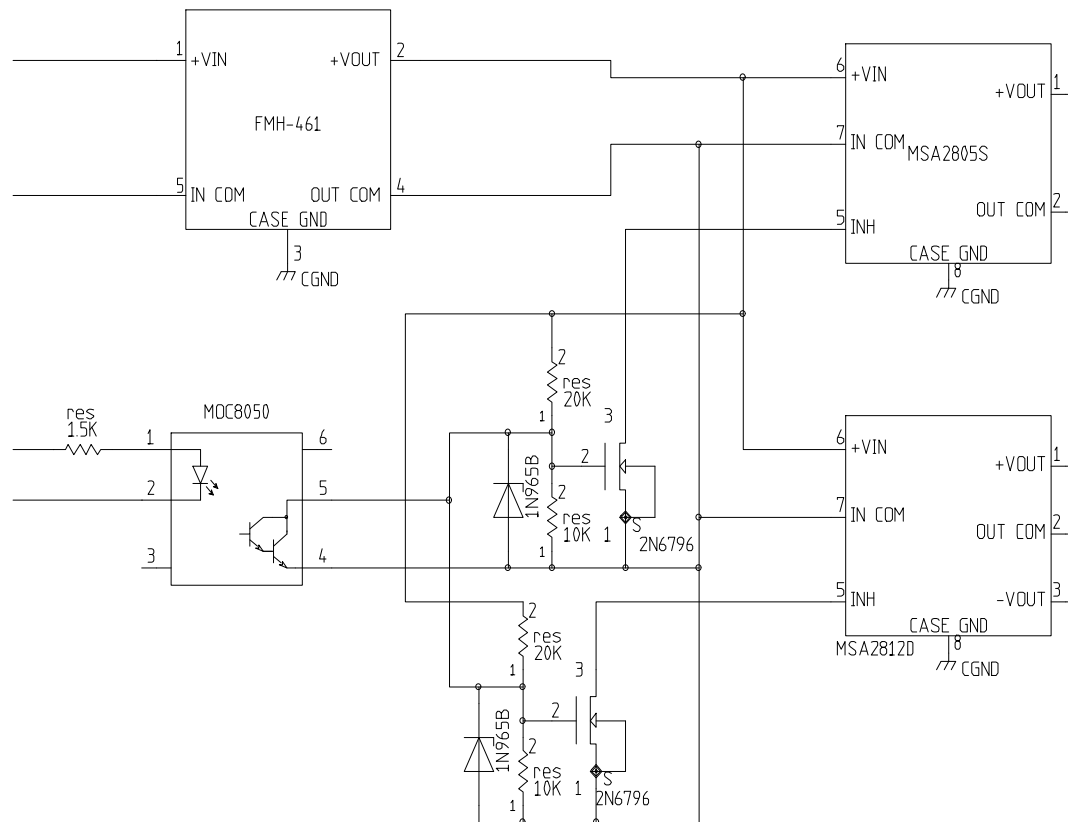
C.O.T.S Supplies								
Supply P.N.	Output Voltages	Maximum Power Available at Each Output (Watts)	Maximum Total Output Power (Watts)	Supply Qty.	Total Maximum Power Available at Each Output (Watts)	Total Maximum Total Output Power (Watts)	Scanner Load (Watts)	Spare Capacity (Watts)
MHF2812D/ES	+12 VDC	10.80	12.00	1	10.80	12.00	8.400	3.60
	-12 VDC	10.80			10.80			
MTR2805S/ES	+5 VDC	25.00	25.00	1	25.00	25.00	20.000	5.000

SCANNER SUPPLIES		REGULATION	REGULATION REQUIREMENT
MHF2812D/ES	+12 VDC	+/- 0.100 VDC	+/- 0.36 VDC
	-12 VDC	+/- 0.300 VDC	+/- 0.36 VDC
MTR2805S/ES	+5 VDC	+/- 0.100 VDC	+/- 0.15 VDC

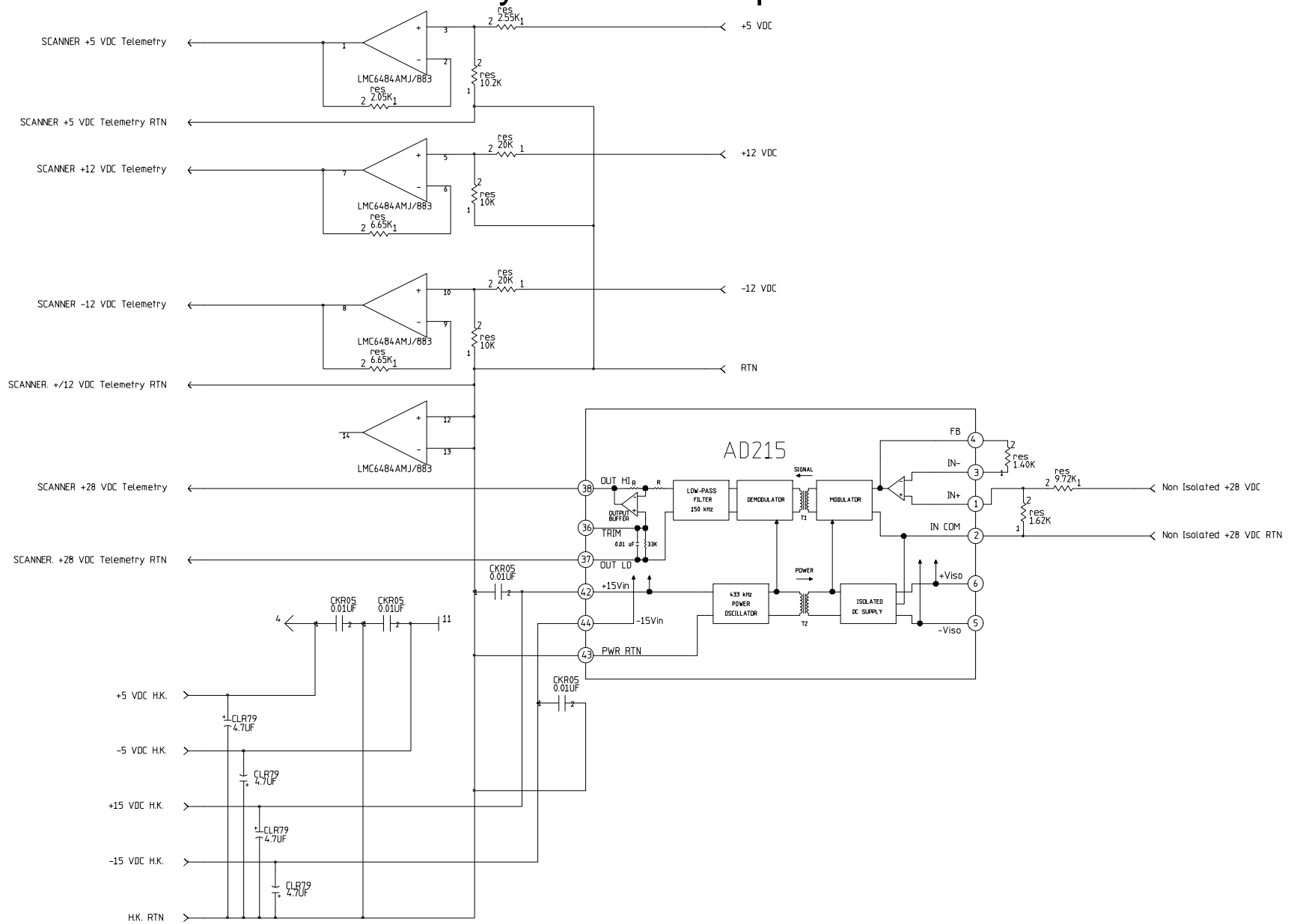
SCANNER C.O.T.S. POWER SUPPLY FILTERS

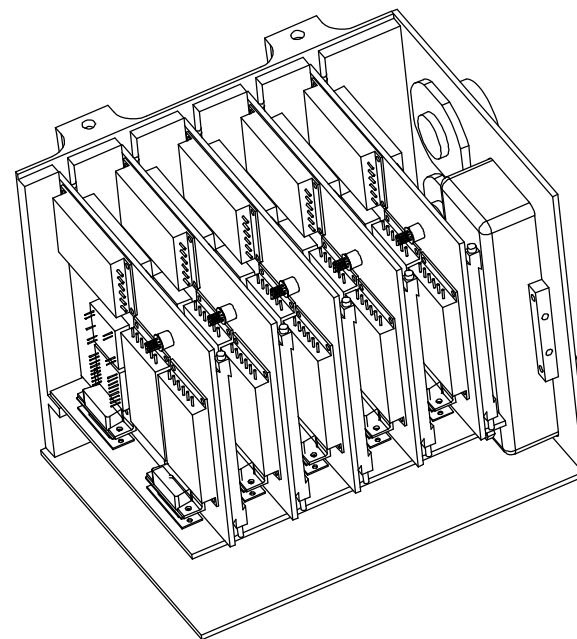
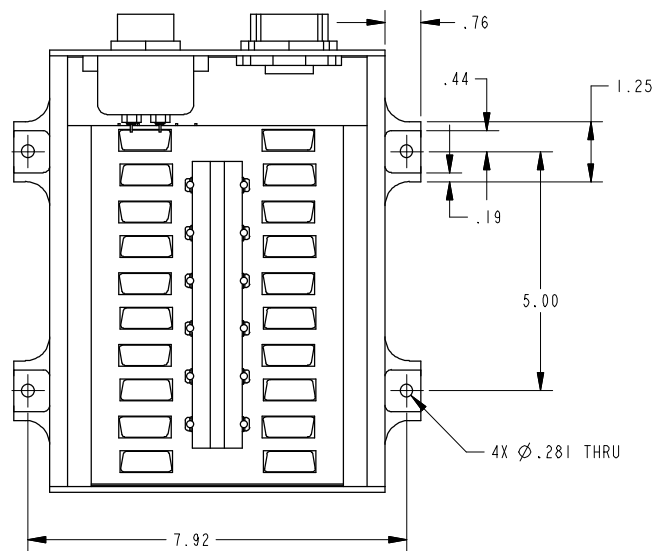
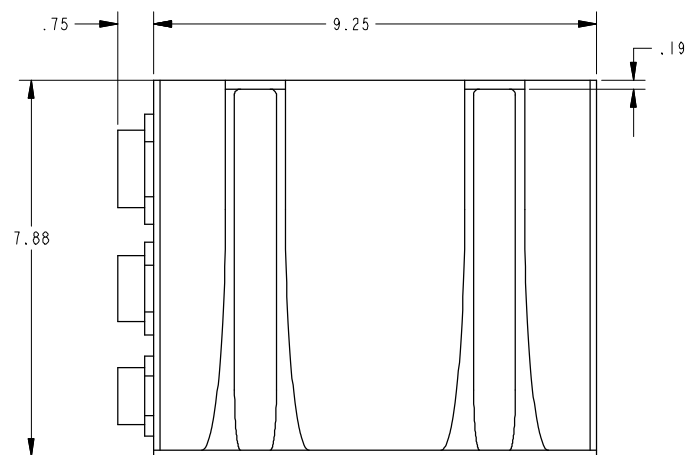
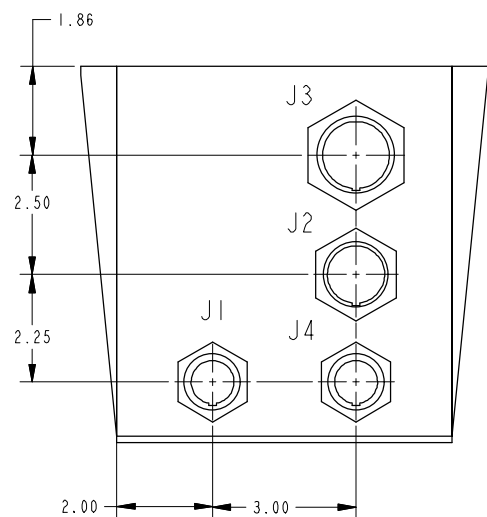
Filter P.N.	Throughput Current (Amps.)			
FME28-461	15.00			
Supplies Connected to Filter	Supply Output Power (Watts)	Supply input current at 23 VDC assuming 75% efficiency (Amps.)	Supply Qty.	Total Input Current (Amps.)
MHF2812D/ES	12.00	0.70	1	0.70
MTR2805S/ES	25.00	1.45	1	1.45
		Total:		2.14

Inhibit Control Circuit Example



Telemetry Circuit Examples

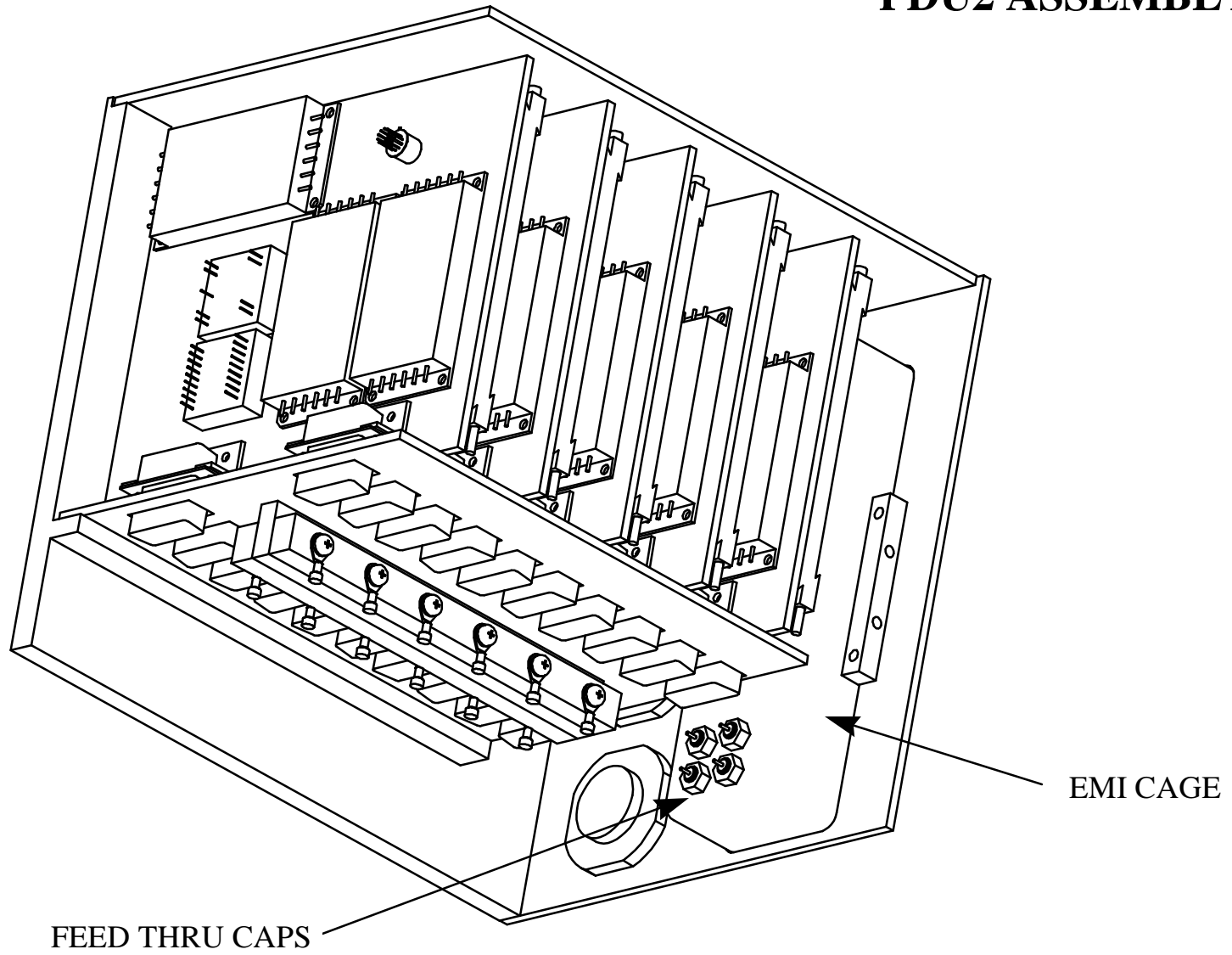


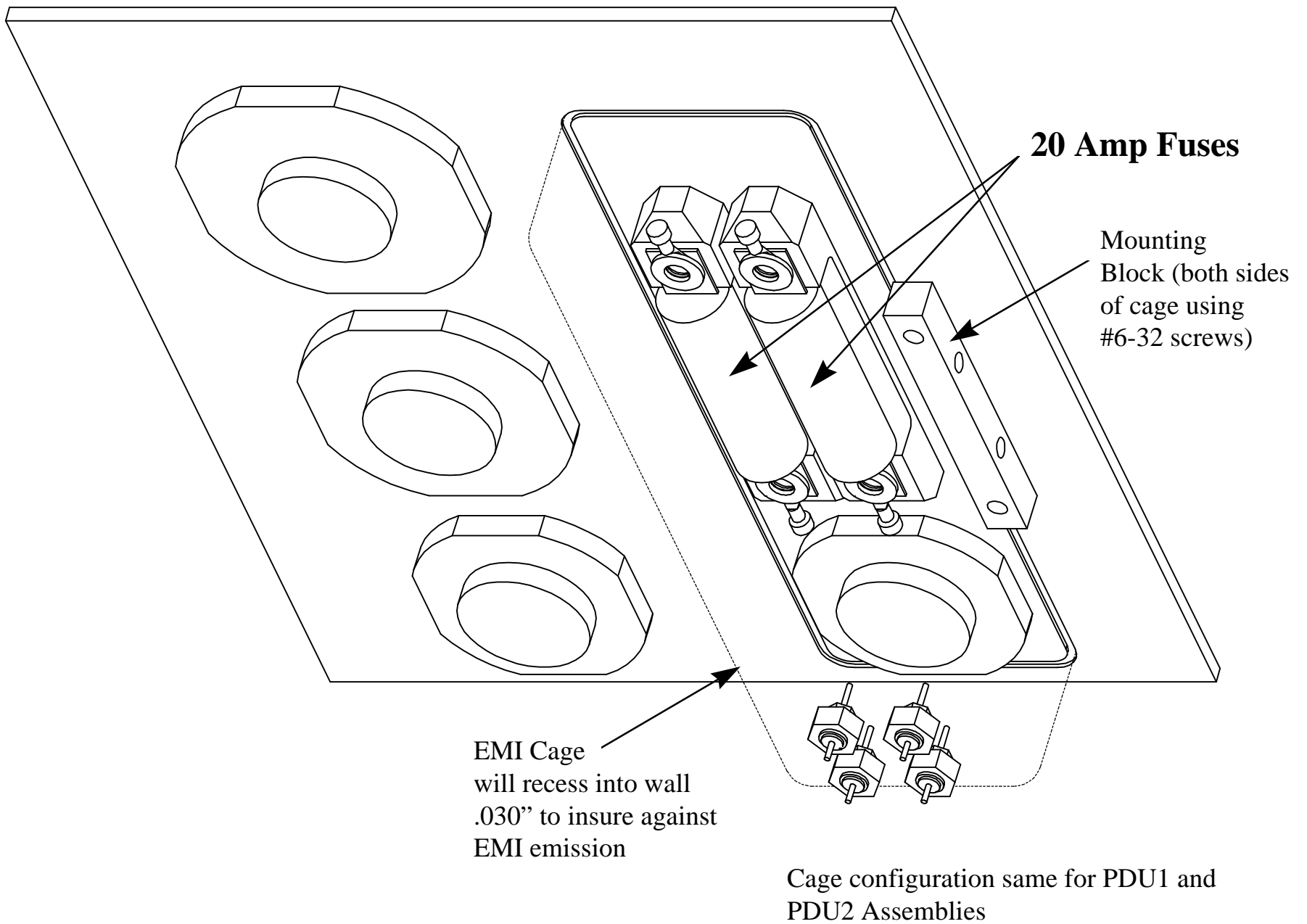


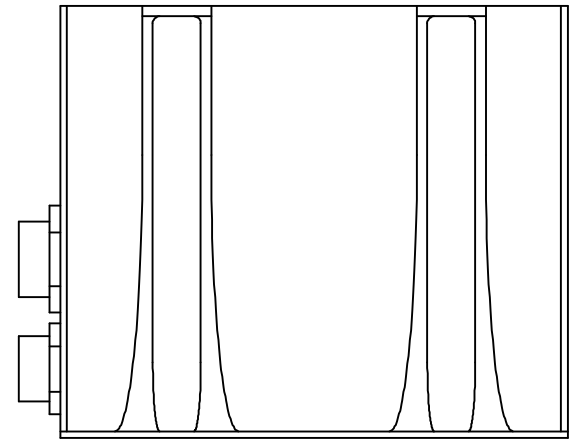
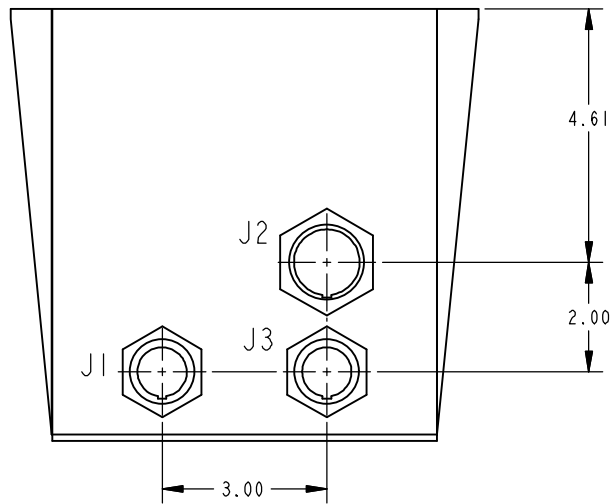
PDU2 ASSEMBLY

10/1/98

PDU2 ASSEMBLY

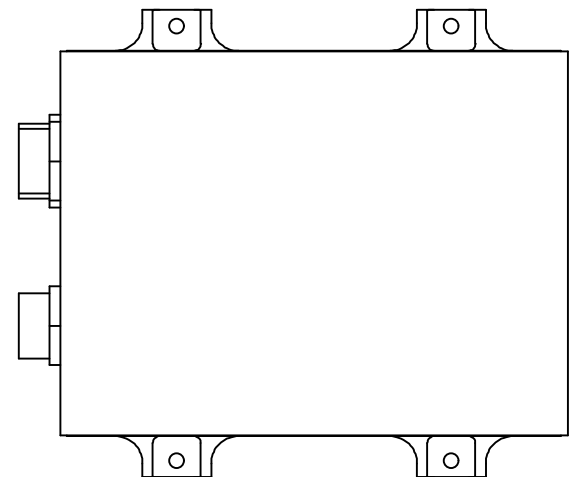






PDU1 ASSEMBLY

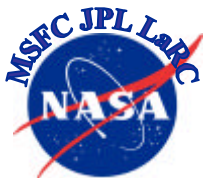
Note: Overall box dimensions are the same as the PDU2 BOX



Concerns

== SPARCLE PDR ==

- **6 months between PDR and CDR**
 - Cannot afford power requirement changes after PDR.
 - Cannot afford power requirements to be TBD after PDR.
- **Manufacturing support must be available**
 - Shop support must be available to fabricate PDU engineering unit in a timely fashion.
- **Procurement of parts.**
 - Delays in awarding procurements will have an impact in building the PDU engineering unit
- **Preliminary peak power analysis shows exceedance of 1,000 W budget.**



Conclusions

== SPARCLE PDR ==

- Based upon our understanding of the requirements levied upon us by Hitchhiker, SPARCLE, and the subsystems; we are developing a PDU design which will comprise of both commercial off-the-shelf hardware and in-house designs. An engineering unit shall be fabricated and tested to verify the design meets these requirements. At the same time we shall work towards either eliminating or minimizing identified concerns.

